

# **CHAPTER 3**

## **SCHEMATIC READING**

### **LEARNING OBJECTIVES**

Upon completing this chapter, you should be able to:

1. Recognize the marking system for cables to include shipboard and test equipment systems.
2. Recognize the marking system for wire to include aircraft and shipboard electronic equipment systems.
3. Recall the seven types of electrical diagrams and the functional design of each.
4. Recall basic safety practices and precautions for working around electrical and electronic systems.

### **SCHEMATIC READING**

This chapter is divided into three subtopics—(1) cable and wire-marking systems, (2) electrical and electronic diagrams, and (3) safety precautions. First, we will discuss the systems used for marking cables and wires. We will then explain each of the types of diagrams you will encounter when troubleshooting, testing, repairing, or learning about circuit or system operation. Finally, we will briefly discuss safety practices relating to working around electrical and electronic systems.

### **CABLE- AND WIRE-MARKING SYSTEMS**

Cables and wires are marked to give the technician a means of tracing them when troubleshooting and repairing electrical and electronic systems.

Numerous cable- and wire-marking systems are used in ships, aircraft, and equipment throughout the Navy. A few of these systems are briefly discussed here to acquaint you with how marking systems are used. For a specific system or equipment, you should refer to the applicable technical manual.

#### **CABLE-MARKING SYSTEMS**

Two typical cable-marking systems you are likely to see are the (1) shipboard and (2) test equipment cable-marking systems.

##### **Shipboard Cable-Marking Systems**

Metal tags embossed with the cable markings are used to identify all permanently installed shipboard electrical cables. These cable tags (figure 3-1) are placed on cables close to each point of connection, and on both sides of decks, bulkheads, and other barriers to identify the cables. The markings on the cable tags identify cables for maintenance and circuit repairs. The tags show (1) the SERVICE LETTER, which identifies a particular electrical system, (2) the CIRCUIT LETTER or LETTERS, which identify a specific circuit within a particular system, and (3) the CABLE NUMBER, which identifies an individual cable in a specific circuit.

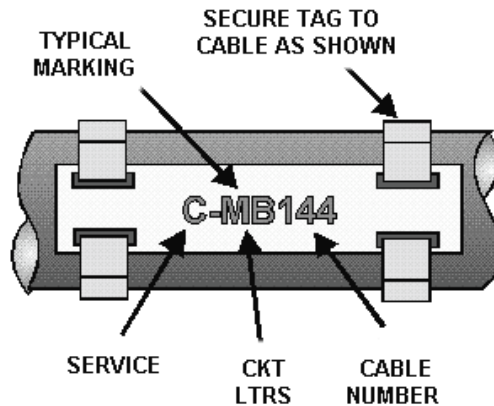


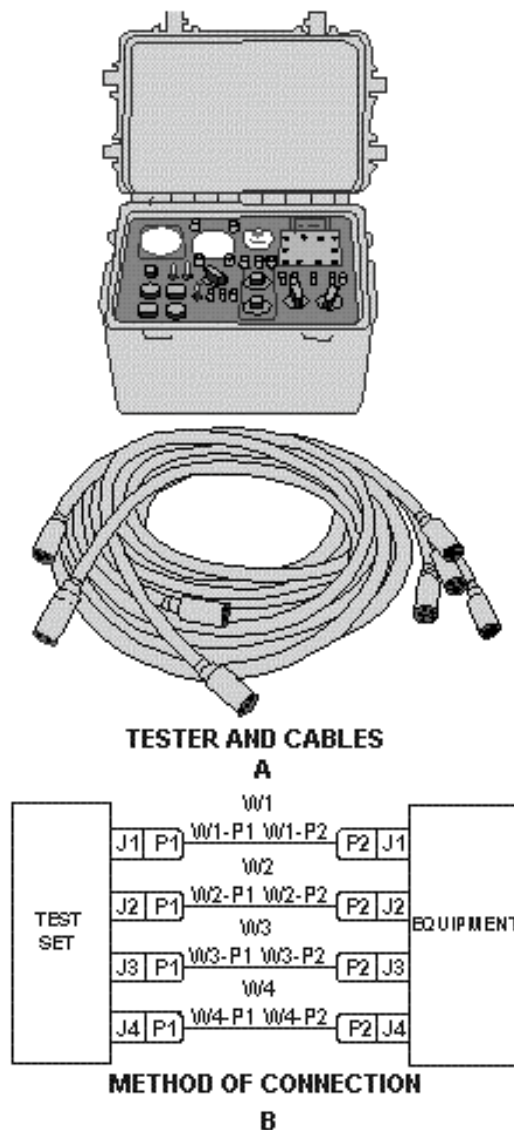
Figure 3-1.—Cable tag.

In figure 3-1, note that the cable is marked "C-MB144." The letter C denotes the service; in this case, the IC (interior communication) system. The letters MB denote the circuit; in this case, the engine-order circuit. The number 144 denotes cable number 144 of the MB circuit.

- Q1. *Why must cables and wires be identified?*
- Q2. *Where would you find the wire identification system for a specific piece of equipment?*
- Q3. *What does the cable number identify?*

### Test Equipment Cable-Marking Systems

View A of figure 3-2 shows a piece of test equipment that is used to check out electrical or electronic equipment or a system. It also shows the cables that are used to hook the tester to the equipment. The cables have metal or plastic tags at each end showing the cable number and the connector number.



**Figure 3-2.—Test equipment cable marking.**

View B of figure 3-2 shows the method of connecting the tester to the piece of equipment to be tested. (For a specific tester, the technical manual supplied with the tester shows the method of connection.) The tester shown has four cables. These are numbered W1, W2, W3, and W4. Each cable has two connectors (plugs), one on each end, that are numbered P1 and P2. The cable tag on one end of the cable reads W1-P1, and the other end reads W1 -P2. As shown in the figure, W1-P1 is connected to the receptacle J1 on the tester. W1-P2 is then connected to receptacle J1 on the equipment to be tested. The same procedure is followed for connecting the remaining three cables. The hookup is then complete.

The shipboard and the test equipment cable markings just discussed are only two of many cable-marking systems you may encounter. There are too many systems to attempt to discuss them all. As stated earlier, you should study an equipment or installation technical manual before attempting repairs or connections.

## WIRE-MARKING SYSTEMS

Wire-marking systems are used to identify wires in aircraft, shipboard electronic equipment, and power tool and appliance cables.

### Aircraft Wire-Marking Systems

All aircraft wiring is identified on wiring diagrams exactly as the wire is marked in the aircraft. Each wire is coded by a combination of letters and numbers (figure 3-3) imprinted on the wire at prescribed intervals along the wire run.

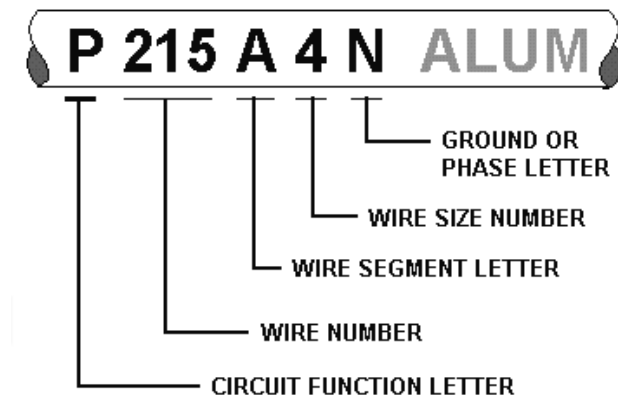


Figure 3-3.—Aircraft wire marking.

Look at figure 3-3. The circuit function letter (P in this example) identifies the basic function of the circuit concerned. The letter P indicates that the wire is in the dc power distribution system of the aircraft. The wire number, 215, indicates that it is the 215th wire in the dc distribution system. The wire segment letter (A) identifies the position of each wire segment of the circuit. The wire segments are lettered in alphabetical sequence and change each time the wire passes through a terminal or connector. For example, after the wire passes through the first terminal or connector, the segment letter A, as in this instance, would change to B.

The wire size number (4) is the AN wire size. AN wire sizes have more strands for flexibility and are slightly different in circular mil area than AWG (American Wire Gauge) wire sizes. The current-carrying capacity of each is almost the same. The last letter (N) is the ground or phase letter. The letter N identifies any wire that completes the circuit to the ground network of the aircraft.

In a 3-phase ac power distribution system, a phase letter (A, B, or C) is used as the last letter of the wire marking. If aluminum wire is used as the conductor, ALUMINUM or ALUM will be added as a suffix to the wire identification code.

*Q4. If a wire passes through a connector what portion of the aircraft wire identification number changes?*

### Shipboard Electronic Equipment Wire-Marking Systems

The following explanation is an example of the type of conductor marking used in shipboard electronic equipment. These conductors may be contained in cables within the equipment. Cables within equipment are usually numbered by the manufacturer. These numbers will be found in the technical

manual for the equipment. If the cables connect equipment between compartments on a ship, they will be marked by the shipboard cable-numbering system previously described.

On the conductor lead, at the end near the point of connection to a terminal post, spaghetti sleeving is used as a marking material and an insulator. The sleeving is marked with identifying numbers and letters and then slid over the conductor. The marking on the sleeving identifies the conductor connections both "to" and "from" by giving the following information (figure 3-4):

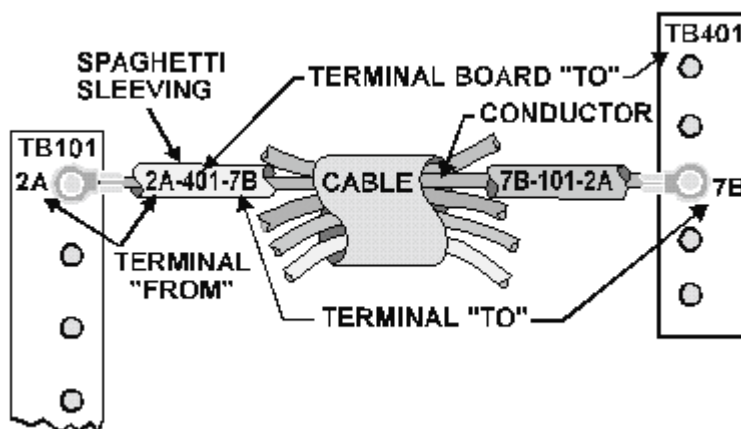


Figure 3-4.—Designating conductor marking between unlike terminals.

The terminal "from"

The terminal board "to"

The terminal "to."

These designations on the sleeving are separated by a dash. The order of the markings is such that the first set of numbers and letters reading from left to right is the designation corresponding to the terminal "from" which the conductor runs. Following this is the number of the terminal board "to" which the conductor runs. ("TB" is omitted when the sleeve is marked.) The third designation is the terminal "to" which the conductor runs.

For example, as shown in figure 3-4, the conductor is attached to terminal 2A of terminal board 101 (terminal "from" 2A on the spaghetti sleeving). The next designation on the sleeving is 401, indicating it is going "to" terminal board 401. The last designation is 7B, indicating it is attached "to" terminal 7B of TB 401. The spaghetti marking on the other end of the conductor is read the same way. The conductor is going "from" terminal 7B on terminal board 401 "to" terminal 2A on terminal board 101.

On occasion, it may be necessary to run conductors to units that have no terminal board numbers; for example, a junction box. In this case, an easily recognizable abbreviation may be used in place of the terminal board number on the spaghetti sleeving. The designation "JB2" indicates that the conductor is connected to junction box No. 2. A conductor to junction box No. 2 of a piece of equipment would be identified as shown in figure 3-5. In the same manner, a plug would be identified as "P." This P number would be substituted for the terminal board number marking on the sleeving.

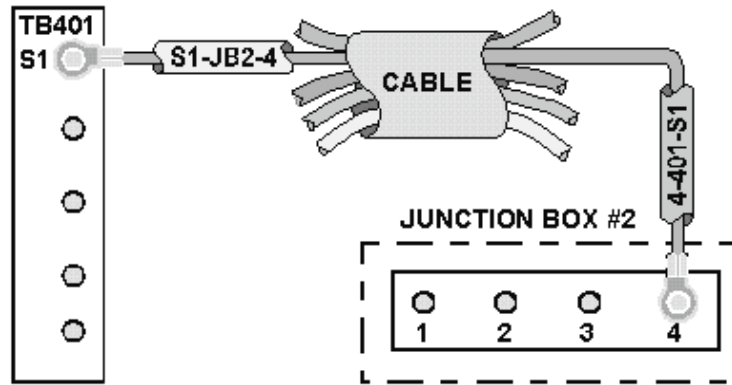


Figure 3-5.—Marking of conductors running to a junction box.

### POWER TOOL AND APPLIANCE MARKING SYSTEMS

As with the wire- and cable-numbering systems discussed so far, there are many color-coding systems used in electrical and electronic applications. The color-coding system discussed here is the one used to code conductors for power tools and appliances.

An electrical power tool or appliance is required to have a three-wire cable. The conductors in the cable are color-coded black, white, and green. At shore bases or civilian facilities, one side of the electrical input is grounded. The grounded side is called the "common," and is color-coded white. The other side of the input is called the "line," or hot side, and is color coded "black". The green conductor is connected to ground and to the frame of the appliance or tool.

Aboard ship, neither side is grounded; therefore, both sides are considered the "line," or both are hot. The black or the white conductor may be connected to either line, since there is no difference. The green conductor is connected to ground. Ground aboard ship is the ship's hull.

The purpose of the ground wire (green) is to prevent an electrical shock to the operator in case there is an electrical short to the frame of the appliance or tool.

*Q5. What markings are found on spaghetti sleeving?*

*Q6. What is the purpose of the green conductor in a power tool or electrical appliance cable?*

### ELECTRICAL DIAGRAMS

It is absolutely essential that personnel in the electrical or electronic ratings be able to "read" (interpret) various types of electrical diagrams. Personnel working in these ratings commonly refer to all electrical diagrams as "schematics." This term is not correct, however. A schematic is a specific type of diagram with characteristics of its own and with a specific purpose. Each of the various diagrams discussed in this chapter has a specific purpose and distinguishing features that set it apart from the others. The diagrams discussed may be used for the following purposes:

- To learn a specific system operation
- To locate the components of a system

- To identify the components of a system
- To trace a circuit
- The troubleshoot equipment
- The repair equipment.

When you have completed this subject, you should be able to recognize the relationship between the various diagrams, their distinguishing features, and the purpose of each type of diagram. A continuing reference to the figures in the text should help you understand the subject matter more clearly.

We will use a simplified drawing of the electrical system of an automobile to explain the various electrical diagrams and how to "read" them.

## PICTORIAL DIAGRAM

The simplest of all diagrams is the pictorial diagram. It shows a picture or sketch of the various components of a specific system and the wiring between these components. This simplified diagram provides the means to readily identify the components of a system, even if you are not familiar with their physical appearance. This type of diagram shows the various components without regard to their physical location, how the wiring is marked, or how the wiring is routed. It does, however, show you the sequence in which the components are connected.

Figure 3-6 is a pictorial diagram of an automobile starting and ignition system. If you are not already familiar with the components of this system, study the diagram. You should then be able to recognize the physical appearance of each component and its interconnections with the other components of the system.

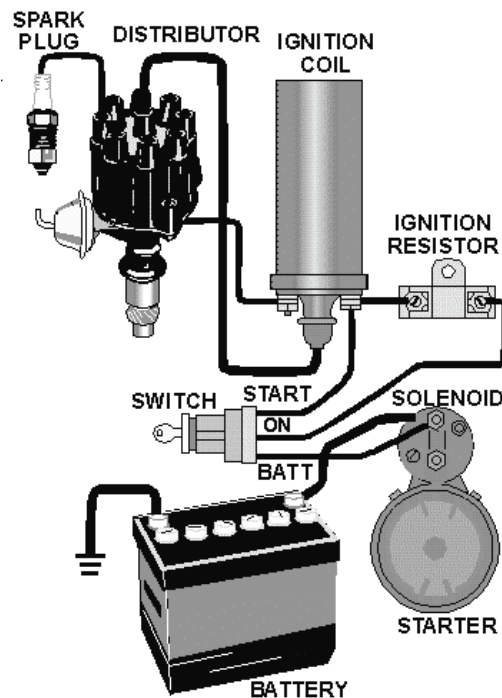


Figure 3-6.—Pictorial diagram of automotive starter and ignition systems.

## ISOMETRIC DIAGRAM

The purpose of an isometric diagram is to assist you in locating a component within a system. If you do not know where to look for a component, the isometric diagram is of considerable value to you. This type of diagram shows you the outline of a ship, airplane, or piece of equipment. Within the outline are drawn the various components of a system in their respective locations. The isometric diagram also shows the interconnecting cable runs between these components.

Figure 3-7 is an isometric diagram of portions of the same automobile starting and lighting systems discussed in the pictorial diagram (figure 3-6). The battery, starter, and other components can now be seen, each in its actual location within the automobile.

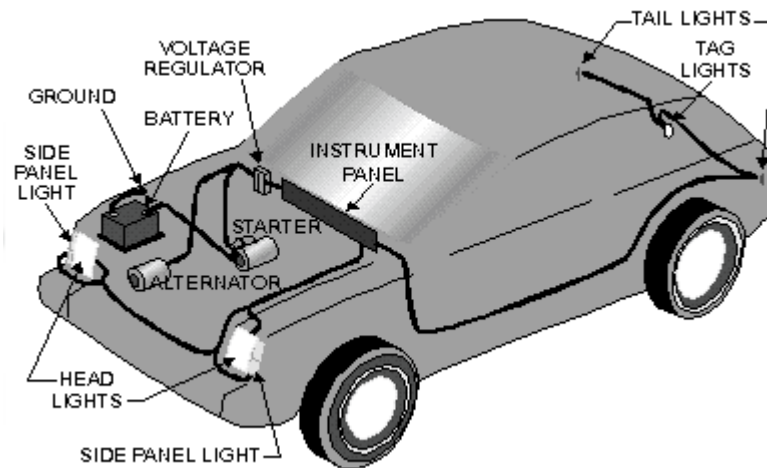
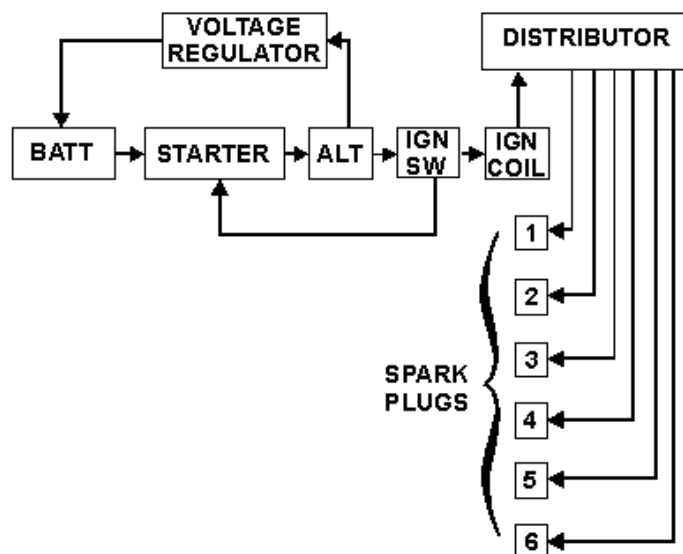


Figure 3-7.—Isometric diagram.

## BLOCK DIAGRAM

A block diagram is used primarily to present a general description of a system and its functions. This type of diagram is generally used in conjunction with text material. A block diagram shows the major components of a system and the interconnections of these components. All components are shown in block form, and each block is labeled for identification purposes.

The block diagram shown in figure 3-8 is an illustration of an automobile's electrical power, starting, and ignition systems. It must be emphasized that the following explanation is primarily for the purpose of assisting you in learning to "read" or interpret a block diagram. The explanation of the functions of the automobile power, starting, and ignition systems is of secondary importance. By tracing from component to component in the block diagram and following the explanation, you are given a general description of the system functions. In addition, you should be able to understand the arrangement of the components in a block diagram.



**Figure 3-8.—Block diagram.**

The battery is the initial source of power for the starter and ignition systems. The starter is turned by power from the battery when the ignition switch is turned to the START position. Power is also supplied, through the ignition switch, to the coil. From the coil, power is supplied to the distributor and finally to the spark plugs for ignition.

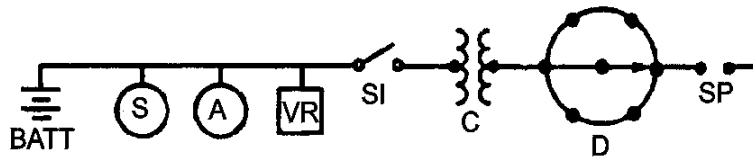
Once the engine is running, the starter is no longer required. The running engine acts as the prime mover for the alternator. (This is accomplished through a belt and pulley system attached to the engine's crankshaft.) The alternator now takes over as the power supplier for the ignition system. It supplies power through the ignition switch to the coil, from the coil to the distributor, and finally from the distributor to the spark plugs. At the same time, the alternator supplies power back through the voltage regulator to the battery for charging purposes. This completes the cycle until the engine is shut down and started again.

Note that the engine is not shown in the block diagram as the prime mover for the alternator. The engine is a mechanical rather than an electrical function. The illustrated block diagram is of the electrical system only. There are block diagrams that show strictly mechanical components or both mechanical and electrical components.

## **SINGLE-LINE DIAGRAM**

The single-line diagram is used basically for the same purpose as the block diagram. When used with text material, it gives you a basic understanding of the functions of the components of a system.

There are two major differences between the single-line diagram and the block diagram. The first difference is that the single-line diagram uses symbols, rather than labeled blocks, to represent components. Second, the single-line diagram shows all components in a single line (figure 3-9). There are no interconnections shown for selected components as were shown on the block diagram (for example, alternator to voltage regulator and back to the battery). The single-line diagram is very simplified and should be used primarily to learn (in very broad terms) the function of each of the various components as a part of the total system.



BATT- BATTERY	SI - IGNITION SWITCH
S - STARTER	C - IGNITION COIL
A - ALTERNATOR	D - DISTRIBUTOR
VR - VOLTAGE REGULATOR	SP - SPARK PLUG

Figure 3-9.—Single-line diagram.

- Q7. What type of electrical diagram is used to identify the components of a system?
- Q8. What type of diagram is used to find the location of a component?
- Q9. What types of diagrams are the most convenient from which to learn the basic Functions of a circuit?

## SCHEMATIC DIAGRAM

The schematic diagram shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. The schematic diagram is used to trace the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts. The schematic diagram is the most useful of all the diagrams in learning overall system operation.

Figure 3-10 is a schematic diagram of an automobile electrical system. The automobile electrical system uses the frame of the automobile as a conductor. The frame is called the ground side. Figure 3-10 shows all the electrical components grounded on one side. The negative side of the battery is also grounded. Therefore, the frame is the negative conductor of the system. The opposite side of each of the components is connected through switches to the positive side of the battery. For the purpose of teaching schematic reading, we will discuss only the lighting system and engine instruments.

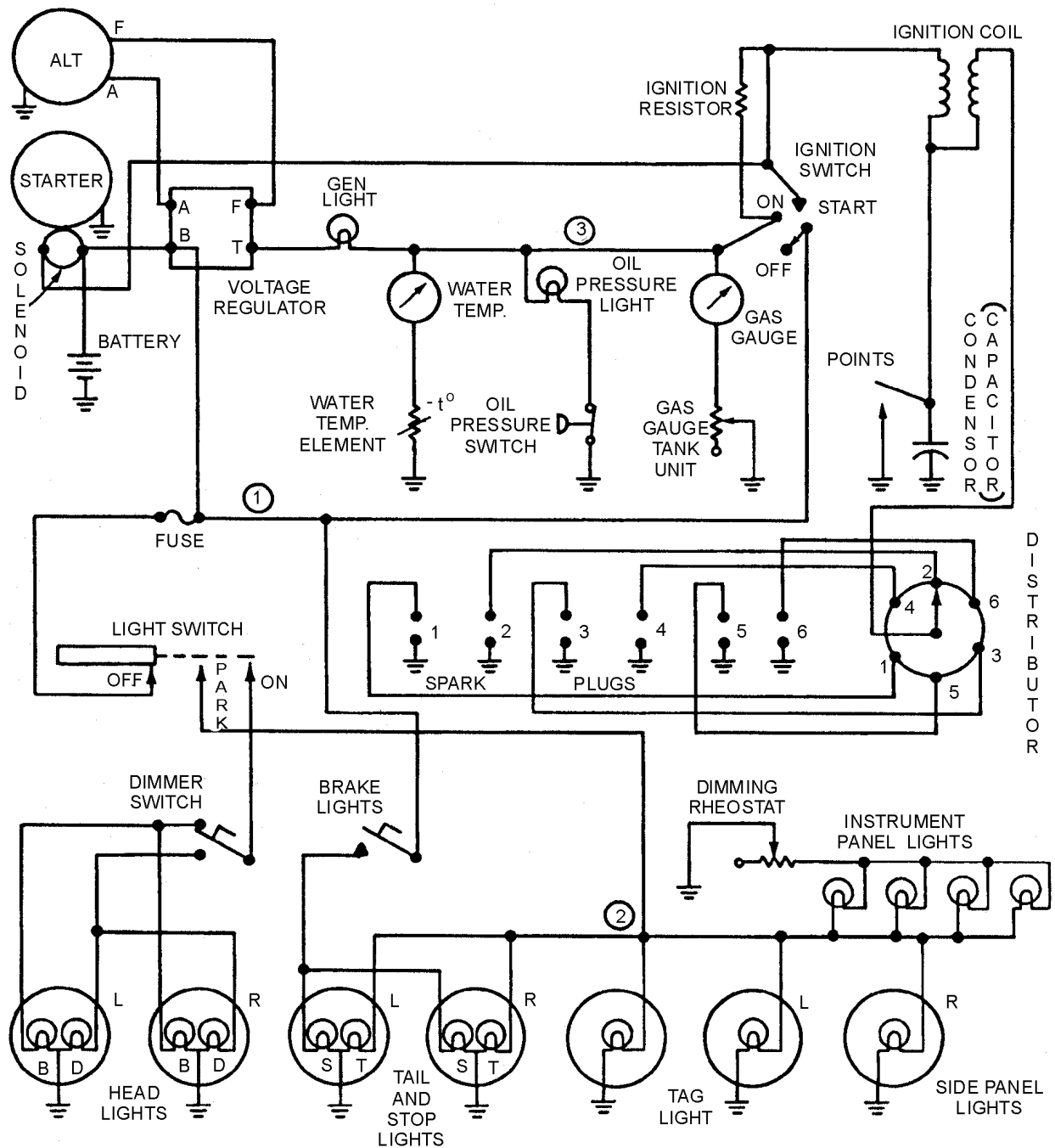


Figure 3-10—Schematic diagram.

The positive side of the 12-volt battery is connected to the starter solenoid, then to terminal B of the voltage regulator, and then down to point (1). (It should be noted that points (1), (2), (3), and so on, normally are not indicated on the schematic. They are shown here only to help you follow the diagram.) Therefore, if no faults are in the system, point (1) has a 12-volt positive potential at all times. This positive potential can be traced through the fuse to the OFF position of the light switch. The dashed line indicates the mechanical linkage of the switch. When the switch is pulled to the first position (park), +12 volts are applied to point (2). It can now be seen that the tail lights (T), the tag light, the side panel lights,

and the instrument lights have +12 volts applied. The opposite side of each light is grounded. The instrument panel lights are grounded through the dimming rheostat. This completes the path for current flow from the negative side of the battery, through all the light bulbs (lamps), back to the positive side of the battery. If no faults exist, the lamps will light.

When the light switch is pulled to the next position (on), the bar on the switch contacts the "off," "park," and "on" contacts of the switch. The lights that were illuminated before are still on, and the + 12 volt potential is now applied to the bright (B) side of the headlights through the dimmer switch. Since the headlights are also grounded on one side, there is now a complete path for current flow, and the headlights also light. If the dimmer switch is actuated, the positive potential is switched from the bright filament to the dim filament of the headlights, and the lights dim.

The brake-light switch has +12 volts applied from point (1), directly to the stop lights (not fused). If the brake pedal is pressed, the switch is actuated, and the +12 volts are applied to both stop lights (S). Because one side of each light is tied to ground, there is a path for current flow, and the lights will light. If the dimming rheostat for the instrument lights is turned in the direction that increases the resistance, more voltage is dropped across the rheostat, less across the lights, and the lights will get dimmer.

The +12 volts at point (1) are also supplied to the OFF position of the ignition switch. When the ignition switch is turned on, the +12 volts are felt at point (3). This is a common point to all the engine instruments.

The gas gauge is a galvanometer with the dial graduated according to the amount of fuel in the tank. The gas gauge tank unit is a rheostat mechanically linked to a float in the gas tank. When the tank is full, the float rises to its highest level and positions the movable arm of the rheostat to a position of minimum resistance. This allows maximum current flow through the galvanometer, and the dial rests at the "full" mark on the gas gauge. As fuel is used by the engine, the float lowers, increasing the resistance of the rheostat to ground. This reduces the current through the galvanometer, and the dial shows a lesser amount of fuel.

The oil-pressure light gets its ground through a normally closed pressure switch. (When no pressure is applied, the switch is closed.) When the engine is started, the oil pressure increases and opens the switch. This turns the light off by removing the ground.

The water-temperature gauge is a galvanometer like the gas gauge, except its dial is graduated in degrees of temperature. The water-temperature element is a thermistor with a negative temperature coefficient. (A thermistor is a semiconductor device whose resistance varies with temperature.) When the engine is cold, the resistance of the thermistor is at a maximum. This reduces the current through the galvanometer, and a low temperature is indicated on the dial. As the water temperature of the engine increases, the resistance of the thermistor decreases. This allows more current to flow from ground through the galvanometer, and the temperature on the dial shows an increase.

On the voltage regulator shown, the "T" terminal is grounded anytime the alternator does not have an output. This gives the alternator light a ground and causes it to illuminate.

- Q10. What type of diagram is the most useful in learning the overall operation of a system?*
- Q11. Refer to the schematic diagram in figure 3-10. If the ignition switch is placed in the ON position and all the engine instruments operate properly except the gas gauge, where would the fault probably be?*
- Q12. If the fuse shown on the schematic (figure 3-10) opens, what lights will operate?*

## WIRING DIAGRAM

A wiring diagram is a detailed diagram of each circuit installation showing all of the wiring, connectors, terminal boards, and electrical or electronic components of the circuit. It also identifies the wires by wire numbers or color coding. Wiring diagrams are necessary to troubleshoot and repair electrical or electronic circuits. The wiring diagram for an automobile is shown in figure 3-11. It shows all the electrical components and that the interconnecting wiring is color coded.

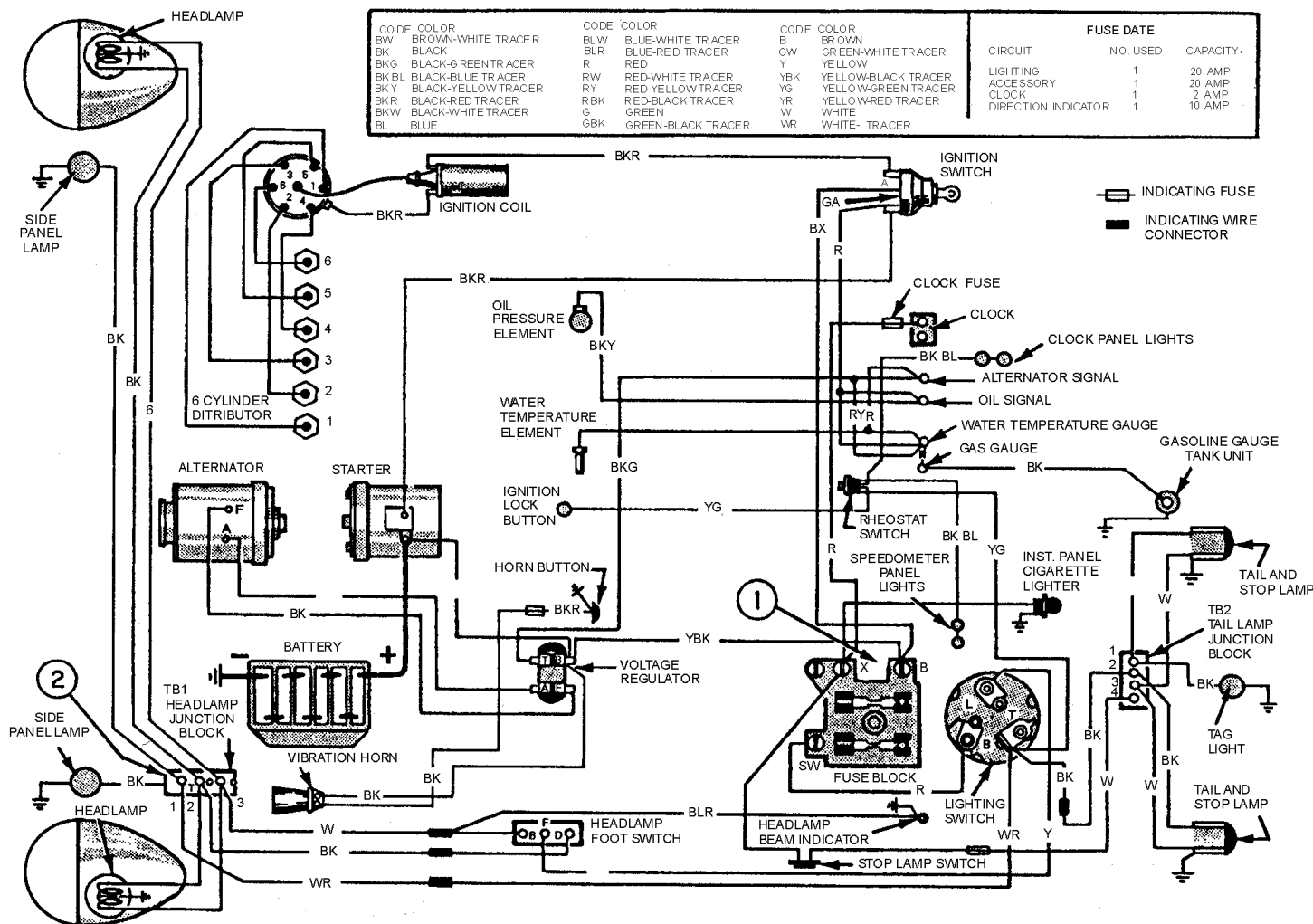


Figure 3-11.—Wiring diagram.

You should use the schematic diagram previously discussed to determine where the trouble might be in the circuit when a malfunction occurs. The schematic diagram does not show the terminals, connector points, and so forth, of the circuit. Therefore, you must go to the circuit wiring diagram to determine where to make the voltage or resistance checks in the circuit when troubleshooting. Following is an example of how to use a schematic diagram in conjunction with a wiring diagram to troubleshoot a circuit.

In the discussion of schematic diagrams, you will recall that when the light switch is pulled to the PARK position, the tail lights, side panel lights, tag light, and the instrument lights come on. Now, suppose that when the light switch is pulled to the PARK position all the lights come on, except the tag

light. Referring to the schematic diagram (figure 3-10), you will recall that when the light switch is placed in the PARK position, +12 volts are applied to point (2). If all the lights come on except the tag light, then the fault must be between point (2) and the tag light ground.

On the schematic shown in figure 3-11, you can see that there are numerous connections to point (2). Point (2) on the wiring diagram is actually composed of three different functions: terminal 1 of TB 1 (the head lamp junction block), terminals 1 and 2 of TB2 (the tail lamp junction block), and the "T" terminal of the light switch; all correspond to point (2) on the schematic. The fault here is in the tag light, which normally receives its +12 volts from terminal 1 of TB2.

To use a voltmeter to find the fault, place the positive lead of the voltmeter to the ground terminal of the tag light and the negative lead to the frame. The voltmeter should read zero, because there should be no difference of potential between the two points. If the meter reads a voltage, the ground lead is either open or has a high-resistance connection. If the meter reads zero, as it should, you will have to go to another test point. In this case, place the positive voltmeter lead on the positive terminal of the tail light. If the voltmeter reads +12 volts, the light bulb is probably burned out or the light socket is defective. If the voltmeter reads zero, then the open is between terminal 1 of TB2 and the light.

## TERMINAL DIAGRAM

A terminal diagram is useful when connecting wires to terminal boards, relays, switches, and other components of a circuit. Figure 3-12 shows two typical terminal diagrams. View A of the figure shows the wire numbers connected to each terminal of a terminal board. View B shows the different color codes of the wires that are connected to a relay.

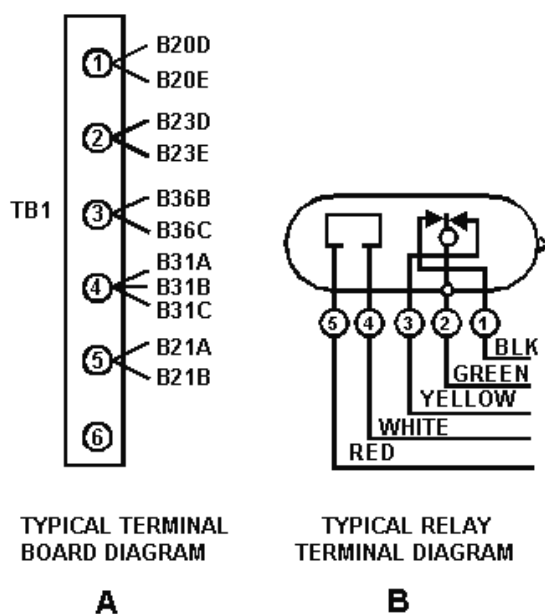


Figure 3-12.—Terminal diagrams.

This has been a brief overview of the use and interpretation of electrical diagrams. The diagrams used were selected because of their simplicity and ease of interpretation. Many diagrams you will encounter are far more complex. Start with the simpler diagrams you will be working with on the job. Your proficiency in using the more complex diagrams will increase with experience and study.

- Q13. What type of diagram is the most detailed?*
- Q14. Why must a wiring diagram be used in conjunction with a schematic to troubleshoot a system?*
- Q15. What type of diagram would be most useful for wiring a relay into a circuit?*

## **SAFETY**

The Secretary of the Navy, in establishing a Department of the Navy safety program, stressed, "Safety is an inherent responsibility of command...." He further outlined that, "Assignment of safety responsibility at all echelons of command is a basic requirement." This means responsibility right down through the lowest rated personnel in the command. Most noncombat accidents can be prevented if all personnel cooperate in eliminating unsafe conditions and acts. To this end, each individual is responsible for understanding and applying safety rules, standards, and regulations in all activities. Safety consciousness will help prevent personal injury and damage to property.

Some safety precautions applicable to this module deal with fumes from synthetic insulation, breathing asbestos fibers, and working around/with electrical and electronic circuits and portable power tools.

## **SYNTHETIC INSULATION**

Almost without exception, the fumes from synthetic materials, such as plastics in high-temperature environments, are objectionable from the standpoint of health and safety. Fluoroplastics (FEP and polytetrafluoroethylene) resist decomposition at higher temperature better than most other plastics.

Exposure to fumes when working with fluoroplastics may cause a temporary flu-like condition similar to the metal fume fever (or "foundryman's fever"). These symptoms are commonly called polymer fume fever. They do not ordinarily occur until several hours after exposure, and pass within 36 to 48 hours, even in the absence of treatment.

One of the largest uses of fluoroplastics is as a wire and cable insulation. When insulated wiring is installed, soldering is a routine fabricating procedure, as is the use of a heated element to remove insulation. In neither of these operations do the combined effects of temperature, quantity of resin, and exposure time produce toxic conditions of significance, as long as normal ventilation is maintained.

Any special practices or precautions that may be required should follow the same common sense rules that apply to all soldering jobs. Prolonged soldering in confined spaces with restricted air circulation will require some ventilation for personal comfort. The same is true for open shop areas where a number of personnel are engaged in soldering or hot-wire stripping. Normal ventilation for personal comfort usually provides adequate safety. However, it is recommended that a small duct fan or "elephant trunk" exhaust be used at the workbench during soldering or wire stripping to carry away any toxic vapors.

## **ASBESTOS**

Although asbestos-free products have been developed, older products containing asbestos materials still exist and continue to be used in the Navy. One such product is asbestos insulation used on wiring in high-temperature areas aboard ships and in aircraft.

Because of the serious health hazards of asbestos exposure, the government has imposed strict occupational health and environmental protection standards for the control of asbestos. These standards must be strictly enforced and followed by all Navy personnel.

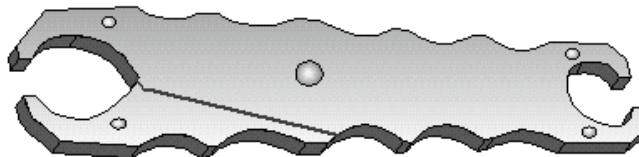
Asbestos is a general term used to describe several fibrous mineral silicates. Major uses of asbestos include asbestos cement products, floor tiles, fireproofing, high-temperature insulation, asbestos cloth, friction materials (such as brake linings and clutch facings), various gasket materials, and miscellaneous other products.

Inhaling asbestos fibers can produce disabling or fatal fibrosis of the lungs. Fibrosis of the lungs (asbestos) comes from inhaling asbestos fibers. Asbestos is a factor in the development of lung cancer as well as cancer of the gastrointestinal tract. It may take 20 to 40 years between initial exposure to asbestos and the appearance of a cancerous condition. Know where asbestos is in your environment and avoid or take precautions to prevent exposure.

## **ELECTRICAL OR ELECTRONIC CIRCUITS AND PORTABLE POWER TOOLS**

When working on electrical or electronic circuits, you must observe certain general precautions. The following is a listing of common sense safety precautions that you must observe at all times:

- Remember that electrical and electronic circuits often have more than one source of power. Take time to study the schematics or wiring diagrams of the entire system to ensure that all power sources are deactivated.
- Remove all metal objects from your person.
- Use one hand when turning switches on or off. Keep the doors to switch and fuse boxes closed, except when working inside or replacing fuses.
- After first making certain that the circuit is dead, use a fuse puller (figure 3-13) to remove cartridge fuses.
- 



**Figure 3-13.—Fuse puller.**

- All supply switches or cutout switches from which power could possibly be fed should be secured in the OFF or OPEN (safety) position and tagged (figure 3-14). The tagging procedures must be done in accordance with the appropriate manual or instruction for your field of training.

<b>SERIAL NO.</b>	<small>SYSTEM COMPONENT IDENTIFICATION</small>		<small>DATE/TIME</small>
	<small>POSITION OR CONDITION OF ITEM TAGGED</small>		
	<h1 style="margin: 0;">DANGER</h1>		
	<h2 style="margin: 0;">DO NOT OPERATE</h2>		
	<small>SIGNATURE OF PERSON ATTACHING TAG</small>	<small>SIGNATURE OF PERSONS CHECKING TAG</small>	
	<small>SIGNATURE OF AUTHORIZING OFFICER</small>	<small>SIGNATURE OF REPAIR ACTIVITY REPRESENTATIVE</small>	

# DANGER

**DO NOT OPERATE**

**OPERATION OF THIS EQUIPMENT WILL  
ENDANGER PERSONNEL OR HARM THE  
EQUIPMENT. THIS EQUIPMENT SHALL  
NOT BE OPERATED UNTIL THIS TAG  
HAS BEEN REMOVED BY AN AUTHOR-  
IZED PERSON.**

Figure 3-14.—DANGER tag.

- Keep clothing, hands, and feet dry if possible. When it is necessary to work in wet or damp locations, use a dry platform or wooden stool to sit or stand on, and place a rubber mat or other nonconductive material on top of the wood. Use insulated tools and molded insulated flashlights when you are required to work on exposed parts. In all instances, repairs on energized circuits must not be made with the primary power applied, except in an emergency, and then only after specific approval has been given by your commanding officer. When approval has been obtained to work on equipment with the power applied, keep one hand free at all times (BEHIND YOU OR IN YOUR POCKET).
- Never short out, tamper with, or block open an interlock switch.
- Keep clear of exposed equipment; when it is necessary to work on it, work with one hand as much as possible.
- Avoid reaching into enclosures, except when it is absolutely necessary. When reaching into an enclosure, use rubber blankets to prevent accidental contact with the enclosure.
- Make certain that equipment is properly grounded.

- Turn off the power before connecting alligator clips to any circuit.
- Never use your finger to test a "hot" line. Use approved voltmeters or other voltage-indicating devices.

### **High Voltage Precautions**

In addition to observing the general precautions just discussed, you must observe the following additional precautions when working with high voltages:

- Do NOT work with high voltage by yourself; have another person (safety observer), qualified in first aid for electrical shock, present at all times. This individual, stationed nearby, should also know the circuits and location of the switches controlling the equipment, and should be given instructions to pull the switch immediately if anything unforeseen happens.
- Always be aware of the nearness of high-voltage lines or circuits. Use rubber gloves where applicable and stand on approved rubber matting. Not all so-called rubber mats are good insulators.
- Always discharge the high voltage from components or terminals by using a safety probe.
- Do NOT hold the test probe when circuits over 300 volts are tested.

### **Soldering Irons**

When using a soldering iron, always keep in mind the following precautions and procedures:

- To avoid burns, ALWAYS ASSUME that a soldering iron is hot.
- Never rest a heated iron anywhere but on a metal surface or rack provided for this purpose. Faulty action on your part could result in fire, extensive equipment damage, and serious injuries.
- Never use an excessive amount of solder, since drippings may cause serious skin or eye burns.
- Do not swing an iron to remove excess solder. Bits of hot solder that are removed in this manner can cause serious skin or eye burns. Hot solder may also ignite combustible materials in the work area.
- When cleaning an iron, use a cleaning cloth, but DO NOT hold the cleaning cloth in your hand. Always place the cloth on a suitable surface and wipe the iron across it to prevent burning your hand.
- Hold small soldering jobs with pliers or a suitable clamping device to avoid burns. Never hold the work in your hand.
- Do not use an iron that has a frayed cord or damaged plug.
- Do not solder components unless the equipment is disconnected from the power supply circuit. Serious burns or death can result from contact with a high voltage.

- After completing the task requiring the use of soldering iron, disconnect the power cord from the receptacle and, when the iron has cooled, stow it in its assigned storage area.

### **Portable Electric Power Tools**

Navy specifications for portable electric power tools require that the electric cord of each tool have a distinctively marked ground wire in addition to the conductors for supplying power to the tool. (Double-insulated portable electric tools obtained from sources qualified under the applicable military specification are exempt from this grounding requirement.) The end of the ground wire within the tool must be connected to the metal housing of the tool. The other end must be connected to a positive ground. For this ground connection, specifically designed ground-type plugs and receptacles, which automatically make this connection when the plug is inserted into the receptacle, must be used. These grounded-type receptacles must be installed for all power outlets. When installed, they must be used with the grounded-type plugs to ground portable tools and equipment. If grounded-type receptacles have not yet been installed, they must be installed as soon as possible. Portable tools not provided with the ground-type plug, and miscellaneous portable electric equipment that does not have a cord with a ground conductor and grounded plug, must be given a three-conductor cord with a standard Navy grounded-type plug. The ground wire must be connected to a positive ground.

Care must be exercised in connecting the plugs and cords. The grounding conductor of the cord must be connected to the ground contact of the plug at one end and to the metal equipment housing at the other end. The cord must be arranged so as not to create a tripping hazard. If the conductor connected to the metallic equipment housing is inadvertently connected to a line contact of the plug, a dangerous potential would be placed on the equipment casing. This could result in a fatal shock to the operator. If the cord is pulled loose from the plug, only a qualified electrician is authorized to repair it.

If the grounded-type plugs and receptacles have not been installed in the spaces where a portable tool is to be used, other types of plugs and receptacles may be used only if a separate ground wire is connected between the tool housing and a positive ground. When the tool cord does not include an extra wire for grounding, an additional insulated wire should be connected between the metal housing of the tool and ground. If the tool housing has two or more conducting parts that are not electrically connected, each part must be connected to the ground wire. Connection of the ground wire to the tool housing and to the ground must be by means of screws or bolts. The use of spring clips for either end of the grounding wire is prohibited.

When the ground connection is to be made by means other than a contact in the plug and receptacle, care must be taken to secure a good contact between the ground wire and the metal by scraping away paint from the metal to ensure a clean surface. The ground connection must be made before inserting the power supply connecting plug, and the plug must be pulled out before removing the ground connection. Frequent inspections of each of the connections of a portable electric tool must be made to ensure that the supply cord and its connections within the tool are suitably insulated and that the ground connection is intact.

The safety precautions just discussed are to protect you and your shipmates. Follow safety precautions to the letter. **DO NOT TAKE CHANCES.** Carelessness could cost you your life.

*Q16. What safety precaution must you observe when soldering or hot-wire stripping fluoroplastic insulated wire?*

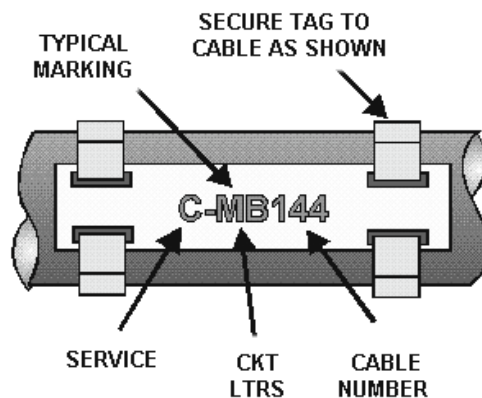
*Q17. What must be used to test an activated circuit?*

*Q18. How should excess solder be removed from a hot soldering iron?*

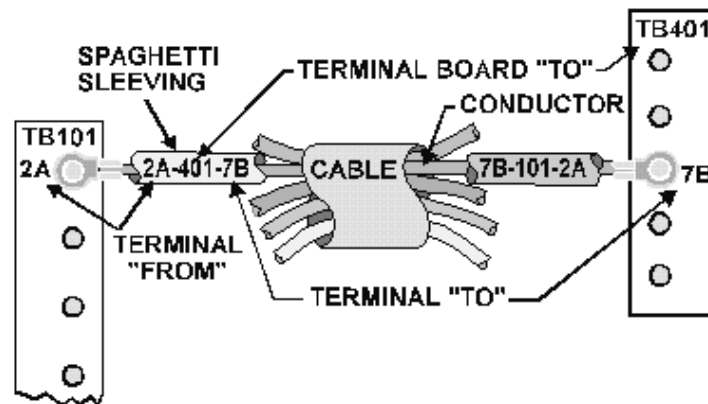
## SUMMARY

In this chapter, we have discussed some typical cable- and wire-marking systems, electrical diagrams, and some basic safety precautions. A brief summary of these subjects follows:

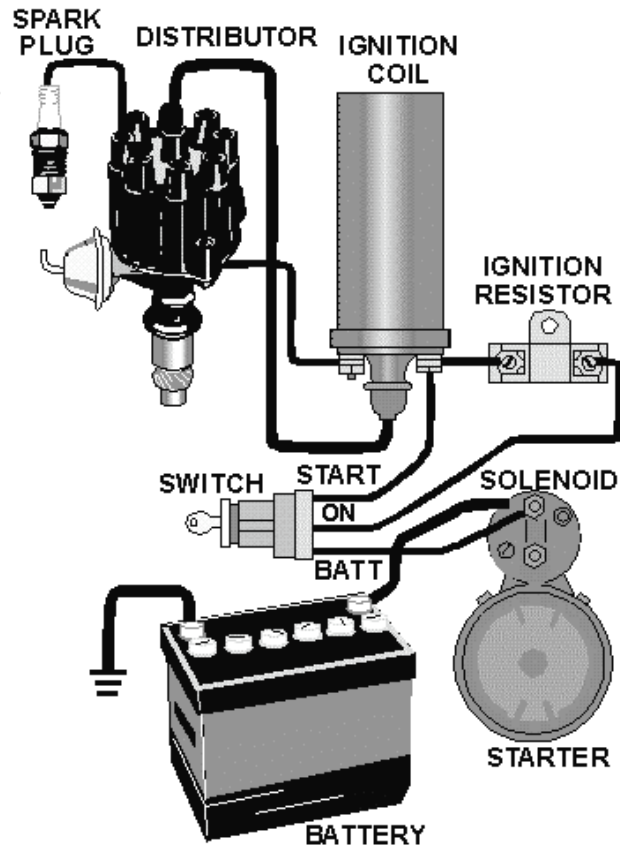
**Cable- and Wire-Marking Systems**—Cables and wires must be identified to provide the technician with a means of tracing them when troubleshooting and repairing electrical and electronic systems. The cable and wire-marking systems discussed in this chapter are typical systems. The number of systems used throughout the Navy is too numerous to discuss. For the cable or wire identification for a specific piece of equipment, consult the technical manual for that equipment. One wire identification system you will surely come in contact with is the color coding of wires used on electrical power tools and appliances. Remember, the purpose of the green conductor in a power tool or appliance cable is to prevent electrical shock to the operator in case there is an electrical short to the frame of the appliance or tool.



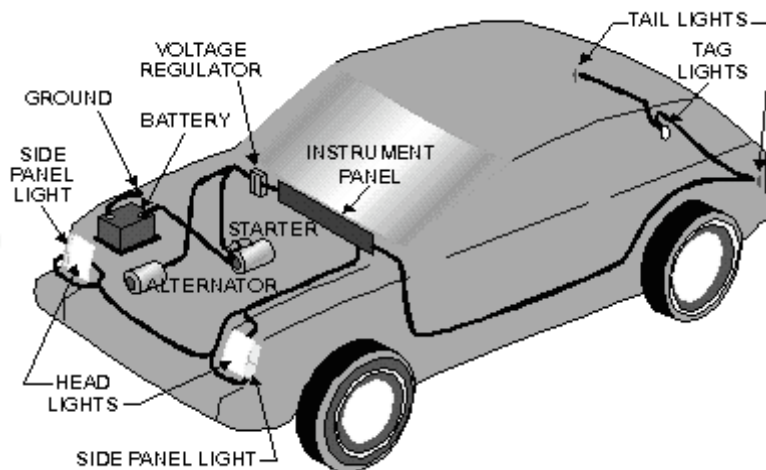
**Electrical Diagrams**—Examples of electrical diagrams you will be required to "read" (interpret) and their uses are as follows:



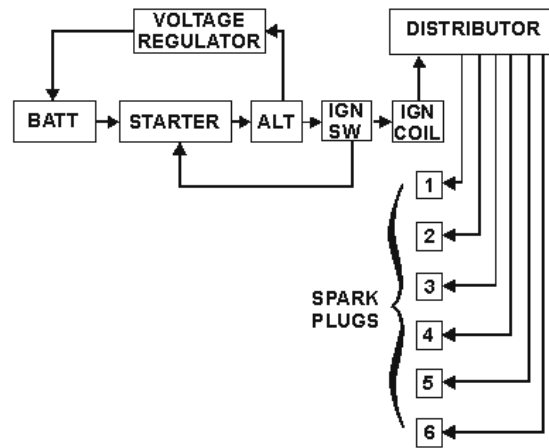
**Pictorial Diagram**—Shows a picture or sketch of the various components of a system and the wiring between the components. This diagram is used to identify the components of a system.



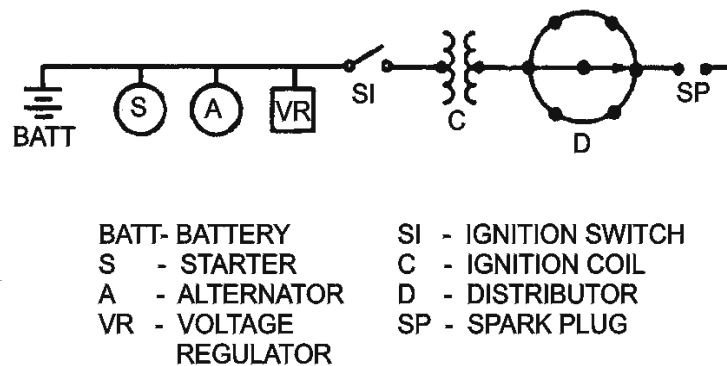
**Isometric Diagram**—Shows the outline of a ship, airplane, or piece of equipment. This diagram shows the components and the cable runs between the components. This diagram is used to locate components in a system.



**Block Diagram**—Shows the components in block form. Block diagrams are used in conjunction with text material. They are used to present a general description of a system and its functions.



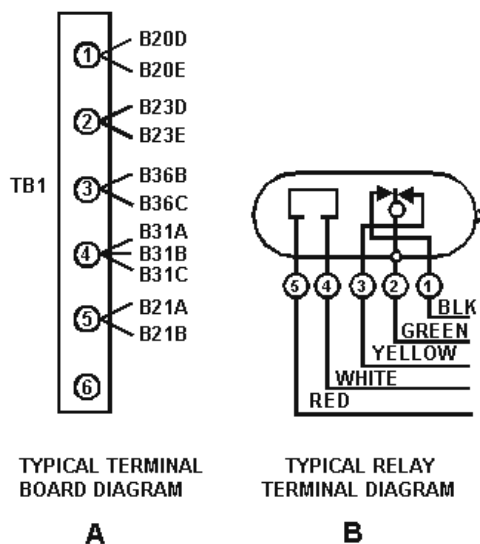
**Single-Line Diagram**—Used for essentially the same purpose as the block diagram—to show the basic functions of a circuit.



**Schematic Diagram**—Shows, through graphic symbols, the electrical connections and functions of a specific circuit arrangement. It is used to trace the circuit without regard to the physical size, shape, or location of the component devices or parts. A schematic diagram shows the overall operation of a system. It is used during troubleshooting to identify possible circuit malfunction locations.

**Wiring Diagram**—Is a detailed diagram of each circuit installation showing all wiring, connectors, terminal boards, and the electrical or electronic components of the circuit. It also identifies the wire-by-wire numbers or color coding. This diagram must be used in conjunction with a schematic diagram to troubleshoot a system in order to find the test point for voltage and resistance checks.

**Terminal Diagram**—Is used in connecting wiring to terminal boards, relays, switches, and other components of a circuit.



**Safety**—All individuals are responsible for understanding and complying with safety standards and regulations established to prevent injury to themselves and others and damage to property and equipment.

Having safe working habits and adhering to safety precautions protects YOU and YOUR SHIPMATES. Follow safety precautions to the letter. DO NOT TAKE CHANCES. Carelessness could cost you your life.

**ANSWERS TO QUESTIONS Q1. THROUGH Q18.**

- A1. *To provide the technician with a means to trace the wires when troubleshooting and repairing electrical and electronic systems.*
- A2. *In the technical manual for the equipment.*
- A3. *Individual cable in a specific circuit.*
- A4. *Wire segment letter.*
- A5. *The conductor connections both "to" and "from."*
- A6. *To prevent electrical shock to the operator in case there is an electrical short to the frame of the appliance or too.*
- A7. *A pictorial diagram.*
- A8. *An isometric diagram.*
- A9. *Block or single-line diagram.*
- A10. *A schematic diagram.*
- A11. *Between point (3) and the gas gauge tank unit ground.*

- A12. Only the brake lights.*
- A13. Wiring diagram.*
- A14. To find the test points.*
- A15. Terminal diagram.*
- A16. Adequate ventilation.*
- A17. Approved meters or other indicating devices.*
- A18. By use of a cleaning cloth.*